PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2002-238144

(43)Date of publication of application : 23.08.2002

(51)Int.Cl. H02G 15/22
H02G 1/06

(21)Application number : 2001-035821

(22)Date of filing : 13.02.2001

(71)Applicant : SUMITOMO ELECTRIC IND LTD
TOKYO ELECTRIC POWER CO INC:THE

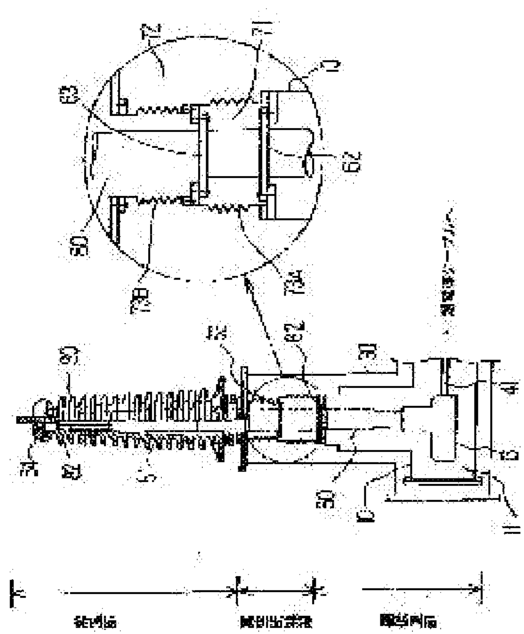
(72)Inventor : ASHIBE YUICHI
HIROSE MASAYUKI
FURUKAWA KOHEI
TAKAHASHI YOSHIHISA
MATSUO KIMIYOSHI
HONJO SHOICHI
MIMURA TOMOO
AIBA TERUMITSU

(54) TERMINAL STRUCTURE OF CRYOGENIC APPARATUS

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a terminal structure for a cryogenic apparatus which has superior heat-insulating properties.

SOLUTION: This terminal structure of a cryogenic apparatus draws out the terminal of a cryogenic apparatus, such as a superconducting cable, etc., from a cryogenic part, into a room-temperature part via a bushing 60. A vacuum heat-insulating part is provided between the cryogenic part and the room- temperature part on the outer circumference of the bushing 60. The vacuum heat-insulating part is formed between a cryogenic side flange 62, which seals the cryogenic part and a room-temperature side flange 63 which seals the room- temperature part.



CLAIMS

[Claim(s)]
[Claim 1]Terminal structure of cryogenic apparatus which is the terminal structure of cryogenic apparatus which pulls out a terminal of cryogenic apparatus from a very-low-temperature part via bushing to a room temperature part, and is characterized by providing a vacuum insulation part in a periphery of said bushing between said very-low-temperature part and a room temperature part.
[Claim 2]Terminal structure of the cryogenic apparatus according to claim 1, wherein said vacuum insulation part was formed between the very-low-temperature side flange which carries out the seal of the very-low-temperature part, and the ordinary temperature side flange which carries out the seal of the room temperature part and said both flanges protrude on a periphery of said bushing.
[Claim 3]Terminal structure of the cryogenic apparatus according to claim 2 having fixed one flange, and constituting a flange of another side free movable so that heat contraction of bushing may be interlocked with.
[Claim 4]Terminal structure of the cryogenic apparatus according to claim 2, wherein said vacuum insulation part is the double structure of an inner layer part and an outer layer part divided mutually.

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention]This invention relates to the terminal structure which pulls out the conductor of cryogenic apparatus in ordinary temperature from very low temperature. It is related with the terminal structure which was excellent in adiathermancy especially.

[0002]

[Description of the Prior Art]Drawing 3 is a schematic diagram showing the conventional terminal structure for cryogenic apparatus.

[0003]This terminal structure is provided with the terminal of the cryogenic apparatus 20 (not shown), the refrigerant tub 10 by which that terminal is stored, the bushing 60 which takes electrical continuity from the conductor of the cryogenic apparatus 20 to a room temperature part, and the insulator 80 which protrudes the outside of the refrigerant tub 10 on the upper part of the wrap vacuum housing 30 and the vacuum housing 30.

[0004]The bushing 60 is mostly connected to the superconducting conductor introduced from the cryogenic apparatus 20 in rectangular directions. The bushing 60 has a conductor at the center, it is what covered solid insulation, such as ethylene propylene rubber, to the circumference, and penetrates the plane of composition of the vacuum housing 30 and the insulator 80, and is stored in the insulator 80. The inside of the insulator 80 is filled up with the insulating fluid 83, such as electrical oil and SF_6.

[0005]In a refrigerant tub, the liquid nitrogen 11 supplied from the feed pipe 32 is stored, and the upper part serves as the nitrogen defects of gas accumulation 15. Discharge of this nitrogen gas can be performed from the gas exhaust 14.

[0006]Therefore, the conduction part from the cryogenic apparatus 20 to the insulator 80 will pass by such terminal structure along the room temperature part in the very-low-temperature part immersed in the liquid nitrogen 11 sequentially from the cable side, the nitrogen defects of

gas accumulation 15, and an insulator.
[0007]
[Problem(s) to be Solved by the Invention]However, there were the following problems in the above-mentioned terminal structure.
** The heat intruding from a room temperature part to a very-low-temperature part is large. When nitrogen defects of gas accumulation exist between the oil level of liquid nitrogen, and the vacuum housing upper surface, it is for heat conduction to occur by the convection of nitrogen gas. As a result of a part for the heat conduction and liquid nitrogen temperature going up and cooling a part for a rise in heat as the measure, energy required for cooling serves as a loss, and causes the increase of a loss of the whole system.
[0008]** It is difficult to consider a refrigerant tub as circulation cooling by a closed system. Usually, a part of bushing is immersed in the refrigerant, and in order to maintain this immersion required range, the oil level of liquid nitrogen is managed. When a refrigerant tub is an open system, an oil level can be maintained by supplying liquid nitrogen, but it is difficult to manage an oil level by pressure variation, change of invasion heat, etc. only by having closed the feed pipe 32 and the outlet 14 as it was, and carrying out circulation cooling.
[0009]Therefore, there is a key objective of this invention in providing the terminal structure of cryogenic apparatus excellent in adiathermancy.
[0010]
[Means for Solving the Problem]This invention attains the above-mentioned purpose by providing a vacuum insulation part between a very-low-temperature part and a room temperature part.
[0011]That is, this invention terminal structure is the terminal structure of cryogenic apparatus which pulls out a terminal of cryogenic apparatus from a very-low-temperature part via bushing to a room temperature part, and provided a vacuum insulation part in a periphery of said bushing between said very-low-temperature part and a room temperature part.
[0012]By making a vacuum insulation part intervene between a very-low-temperature part and a room temperature part, heat conduction by a convection which became a problem in a nitrogen gas part conventionally can be avoided, and high adiathermancy can be realized. Corresponding to this high adiathermancy, circulation cooling by a closed system is easily realizable.
[0013]As for said vacuum insulation part, it is preferred to form between the very-low-temperature side flange which carries out the seal of the very-low-temperature part, and the ordinary temperature side flange which carries out the seal of the room temperature part. These both flanges protrude on a periphery of said bushing.
[0014]In that case, it is preferred to fix one flange to a vacuum housing or a refrigerant tub, and to constitute a flange of another side free movable. Thereby, corresponding to heat elasticity of

bushing, a flange is made movable, and excessive stress is prevented from being applied to one of flanges. Usually, it is preferred to fix the very-low-temperature side flange and to make the ordinary temperature side flange movable.
[0015]It is preferred for a vacuum insulation part to consider it as double structure of an inner layer part and an outer layer part which were divided mutually. In that case, only a case where both an inner layer part and an outer layer part are made into a vacuum, and an inner layer part may be filled up with a gas.
[0016]Since a direction of a very-low-temperature part with which a refrigerant was filled up is high voltage when both inside-and-outside layers are made into a vacuum, it is also considered that a refrigerant of a very-low-temperature part is revealed to a vacuum insulation part. Even in such a case, since it is insulated by vacuum of an outer layer part between a very-low-temperature part and a room temperature part only by the section when only an inner layer part was restricted being full of a refrigerant, by it, an adiathermic fall can be suppressed to the minimum. Therefore, as for an inner layer part, it is preferred to use small space.
[0017]On the other hand, when filling up only an inner layer part with a gas, the gas has the boiling point lower than a refrigerant of a very-low-temperature part, and refrigerant pressure of a very-low-temperature part and a substantially isotonic thing of a gaseous pressure are preferred. If an inner layer part is made isotonic with a very-low-temperature part, disclosure of a refrigerant from a very-low-temperature part to an inner layer part can be prevented. If the gaseous boiling point is made lower than the boiling point of a refrigerant of a very-low-temperature part, a gas will not be liquefied or solidified even if a refrigerant should be revealed to an inner layer part. When a refrigerant of a very-low-temperature part is used as liquid nitrogen, a gas with which an inner layer part is filled up has preferred helium etc.
[0018]If it has a means to detect a pressure of an inner layer part, a pressure buildup of an inner layer part can be detected with disclosure of a refrigerant from a very-low-temperature part, and it can supervise that disclosure of a refrigerant arose.
[0019]As for a flange, it is preferred to constitute from construction material in which bushing and adhesion are possible. For example, it is mentioned that a charge of a principal member of bushing considers it as plastics (epoxy resin etc.) which a charge of a principal member of a flange can paste up on a fiber-reinforced plastic with a fiber-reinforced plastic (FRP).
[0020]As cryogenic apparatus which applies this invention terminal structure, a superconductivity cable, superconductivity stationary-energy-storage apparatus (SMES:Superconducting magnetic energy storage), a superconducting-fault-current-limiting machine, etc. are mentioned. Especially this invention terminal structure is the best for terminal structure of a superconductivity cable for which circulation cooling by a closed system is needed, in order to perform long-distance cooling.
[0021]

[Embodiment of the Invention]Hereafter, an embodiment of the invention is described. Here, the terminal structure of a superconductivity cable is explained as an example. Drawing 1 is a schematic diagram of this invention terminal structure. This terminal structure is provided with the following.
The very-low-temperature part immersed in the liquid nitrogen 11 in the refrigerant tub 10.
The room temperature part stored by the insulator 80.
The vacuum insulation part formed between the very-low-temperature part and the room temperature part.

[0022]The vacuum housing 30 is connected with the heat insulation pipe (not shown) of a superconductivity cable, and a connection part with a vacuum housing and a heat insulation pipe and the inside of a heat insulation pipe are held at a vacuum. The opening diameter of the vacuum housing was set to phi600mm in this example.
[0023]The connected conductors 41 connected with the conductor of a superconductivity cable are introduced into the refrigerant tub 10. The refrigerant tub 10 is a cylinder tube with which the liquid nitrogen 11 is sealed inside. The bushing and cable side set the size both to phi400mm.
[0024]Within this refrigerant tub 10, the connected conductors 41 are connected with the end of the bushing 60 almost right-angled. This connection part is stored in the lower part shield 13.
[0025]The bushing 60 is a rod-like structure of tapered shape [both ends / which laminated FRP and a foil electrode on the periphery of the stainless steel pipe]. Lamination with FRP and a foil electrode is the so-called electric-field-relaxation means of a capacitor method. The electric-field-relaxation means of tapered structure and a capacitor method is an example of bushing, and does not limit the composition of this invention. Bushing of straight pipe structure may be sufficient and the electric-field-relaxation means of a stress cone method may be used.

[0026]An example of the bushing 60 is shown in drawing 2. The flanges 62 and 63 of the couple were united with the periphery of the bushing main part 61. A downward flange is the very-low-temperature side flange 62, and an upper flange is the ordinary temperature side flange 63.
[0027]The flanges 62 and 63 choose the material of a main part periphery, and the thing which is easy to paste up, in order to **** and fit into the main part 61 and to unify by adhesion. Here, the ordinary temperature side flange 63 was made the product made from FRP for the very-low-temperature side flange 62 with the product made from stainless steel. Copper or the upper shield 64 made from aluminum is formed in the upper bed of the bushing 60.
[0028]Let space formed between the very-low-temperature side flange 62 and the ordinary

temperature side flange 63 be a vacuum insulation part by closing the upper bed of the vacuum housing 30 by such an ordinary temperature side flange 63, and closing the upper bed of the refrigerant tub 10 by the very-low-temperature side flange 62 further (drawing 1).
[0029]Here, it constitutes in working using the flexible pipes 73A and 73B which carried out wave attachment processing of the ordinary temperature side flange 63, the ordinary temperature side flange 63 is made movable corresponding to heat elasticity of the bushing 60, and excessive stress is prevented from being applied to the very-low-temperature side flange 62.
[0030]For example, the very-low-temperature side flange 62 is fixed to the upper bed of the refrigerant tub 10, and the lower end of the flexible pipe 73A which encloses the flange 62 is fixed to the upper bed of the refrigerant tub 10. The upper bed of the flexible pipe 73A is fixed to the ordinary temperature side flange 63, and the lower end of the flexible pipe 73B is further connected with the upper bed of the flexible pipe 73A. And the upper bed of the flexible pipe 73B is fixed to the upper bed of the vacuum housing 30.
[0031]A vacuum insulation part is divided into the inner layer part 71 and the outer layer part 72 by the flexible pipe 73A in this composition. The inner layer part 71 is small space enclosed by the outer layer part 72.
[0032]Since application-of-pressure circulation of the liquid nitrogen 11 is stored and carried out at the refrigerant tub 10, if compared with the space held at the vacuum between the refrigerant tub 10 and the vacuum housing 30, the refrigerant tub 10 will be high voltage. Then, if the vacuum insulation part is made into the dual structure of the inner layer part 71 and the outer layer part 72, even if there should be disclosure of the refrigerant from the refrigerant tub 10, will remain in the disclosure in the inner layer part 71, and only by the insulation efficiency of the inner layer part 71 falling. Since the vacuum by the outer layer part 72 is held, the adiathermancy as the whole terminal structure is fully held.
[0033]Here, if the pressure detection means of the inner layer part 71 is formed and the pressure variation of the inner layer part 71 is supervised, it is also detectable that there was leakage of a refrigerant from the refrigerant tub 10 because the pressure increased.
[0034]An inside may be filled up with a gas instead of making the inner layer part 71 into a vacuum. The pressure of the gas in that case presupposes that it is almost as isotonic as the pressure of the liquid nitrogen of the refrigerant tub 10. Thereby, the inside of a refrigerant tub and an inner layer part is held isotonic, and can control disclosure of the refrigerant from the refrigerant tub 10. The gas to be used is made into the thing of the boiling point lower than the boiling point of nitrogen which is a refrigerant, for example, helium. A gas is not liquefied or solidified by the temperature of a refrigerant even if a refrigerant should be revealed to the inner layer part 71.
[0035]Although the above explanation followed the vacuum insulation part of dual structure, in

drawing 1, it removes the flexible pipe 73A and is good also as a vacuum insulation part of a monolayer. Even in this case, since the ordinary temperature side flange 63 is connected with the flexible pipe 73B, it can be made to move corresponding to heat elasticity of bushing.

[0036]And as shown in drawing 1, within the insulator 80, the space between the bushing 60 was filled up with the silicone oil 81 in order to raise the electric surface intensity of a bushing outside surface and an insulator inner surface, and the defects of gas accumulation 82 for corresponding to the volume change accompanying the temperature change of silicone oil were formed in the upper part. The gas of the defects of gas accumulation 82 was made into the helium gas which is not liquefied with liquid nitrogen temperature, either in consideration of gas liquefying, when terminal structure was filled up with liquid nitrogen.

[0037]By providing such a vacuum insulation part, the adiathermancy between a very-low-temperature part and a room temperature part is improved, and terminal structure of the cryogenic apparatus which was dramatically excellent in adiathermancy can be realized. A refrigerant tub is sealed and non supply and the terminal structure of a closed system which circulate and is cooled can be constituted for a refrigerant.

[0038]

[Effect of the Invention]As explained above, according to this invention, forming a vacuum insulation part between a very-low-temperature part and a room temperature part can realize high heat resistance by the terminal structure of cryogenic apparatus, and circulation cooling of the refrigerant non supply by a closed system is enabled.

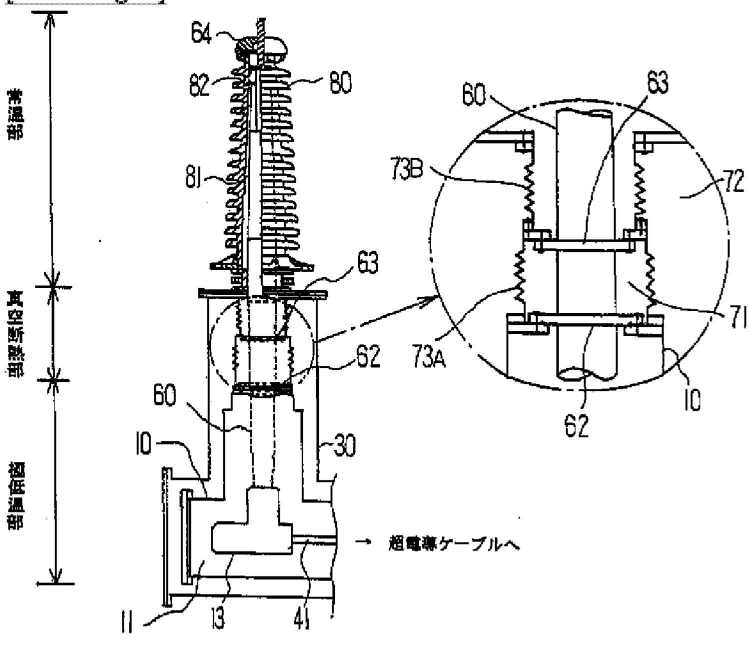
[Translation done.]

* NOTICES *

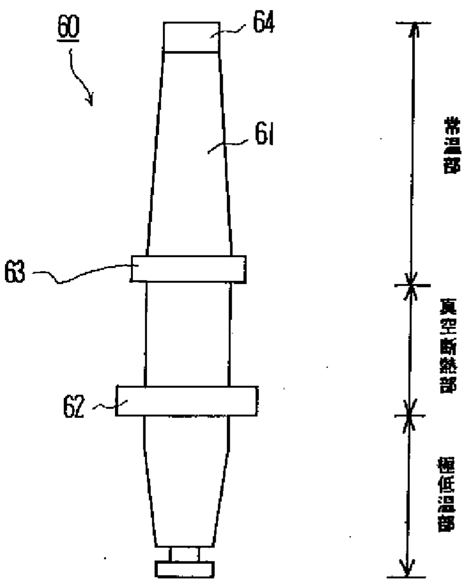
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

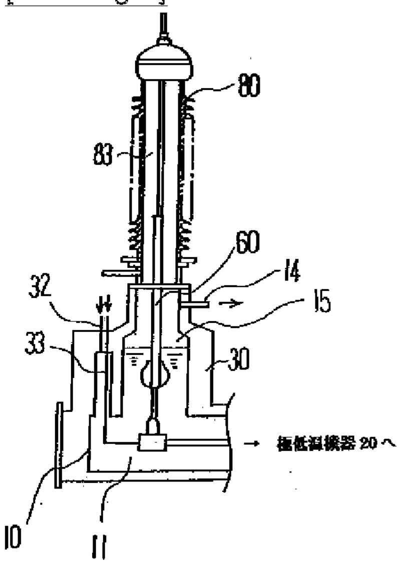
[Drawing 1]



[Drawing 2]



[Drawing 3]



[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1]It is a schematic diagram of this invention terminal structure.
[Drawing 2]It is a side view showing an example of bushing used for this invention terminal structure.
[Drawing 3]It is a schematic diagram showing the conventional terminal structure.
[Description of Notations]
10 Refrigerant tub
11 Liquid nitrogen
13 Lower part shield
14 Gas exhaust
15 Nitrogen reservoir **
20 Cryogenic apparatus
30 Vacuum housing
60 Bushing
61 Main part
62 Very-low-temperature side flange
63 Ordinary temperature side flange
64 Upper shield
71 Inner layer part
72 Outer layer part
73A, 73B flexible pipe
80 Insulator
81 Silicone oil
82 Defects of gas accumulation
83 Insulating fluid

[Translation done.]